



HAL
open science

Sensitivity analysis: a statistical tool for a green roof model analysis

Axelle Hego, Floriane Collin, Hugues Garnier, Rémy Claverie

► **To cite this version:**

Axelle Hego, Floriane Collin, Hugues Garnier, Rémy Claverie. Sensitivity analysis: a statistical tool for a green roof model analysis. Deep Surf 2021, Oct 2021, Nancy, France. hal-03364508

HAL Id: hal-03364508

<https://hal.science/hal-03364508>

Submitted on 4 Oct 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Context

Urban imperviousness is a major urban issue during rainfall

Solution → Green Roofs

- lower the peak flow rate in water system by 22% to 93%
- delay the peak flow by 0 to 30 min

Collaboration

Cerema: Green Roofs experts
CRAN: Model Analysis skills



Collaboration between Cerema and CRAN for a better understanding of the GR behavior

Green Roofs hydrological modeling

- Rainfall data and real water content measured in a green roof of the CEREMA of Nancy (Fig. 1 and Fig. 3)

- Simulation of the water infiltration into the layers using Richards equation (1) implemented in Hydrus-1D[®] software

$$\frac{\partial \theta(h)}{\partial t} = \frac{\partial}{\partial x} \left(K(\theta) \frac{\partial h}{\partial x} \right) - \frac{\partial K(\theta)}{\partial x} \quad (1)$$

combined with Van Genuchten model (2) and Mualem model (3)

$$\theta(h) = \frac{\theta_s - \theta_r}{(1 + |\alpha h|^n)^m} - \theta_r \quad \text{with } m = 1 - \frac{1}{n} \quad (2) \quad K(S_e) = K_s S_e^l \left(1 - (1 - S_e^{1/m})^m \right)^2 \quad \text{with } S_e(\theta) = \frac{\theta(h) - \theta_r}{\theta_s - \theta_r} \quad (3)$$

- Meteorological variables – temperature, air moisture, solar radiation and wind – and vegetation effects are taking into account using the Penman - Monteith equation and Feddes model.

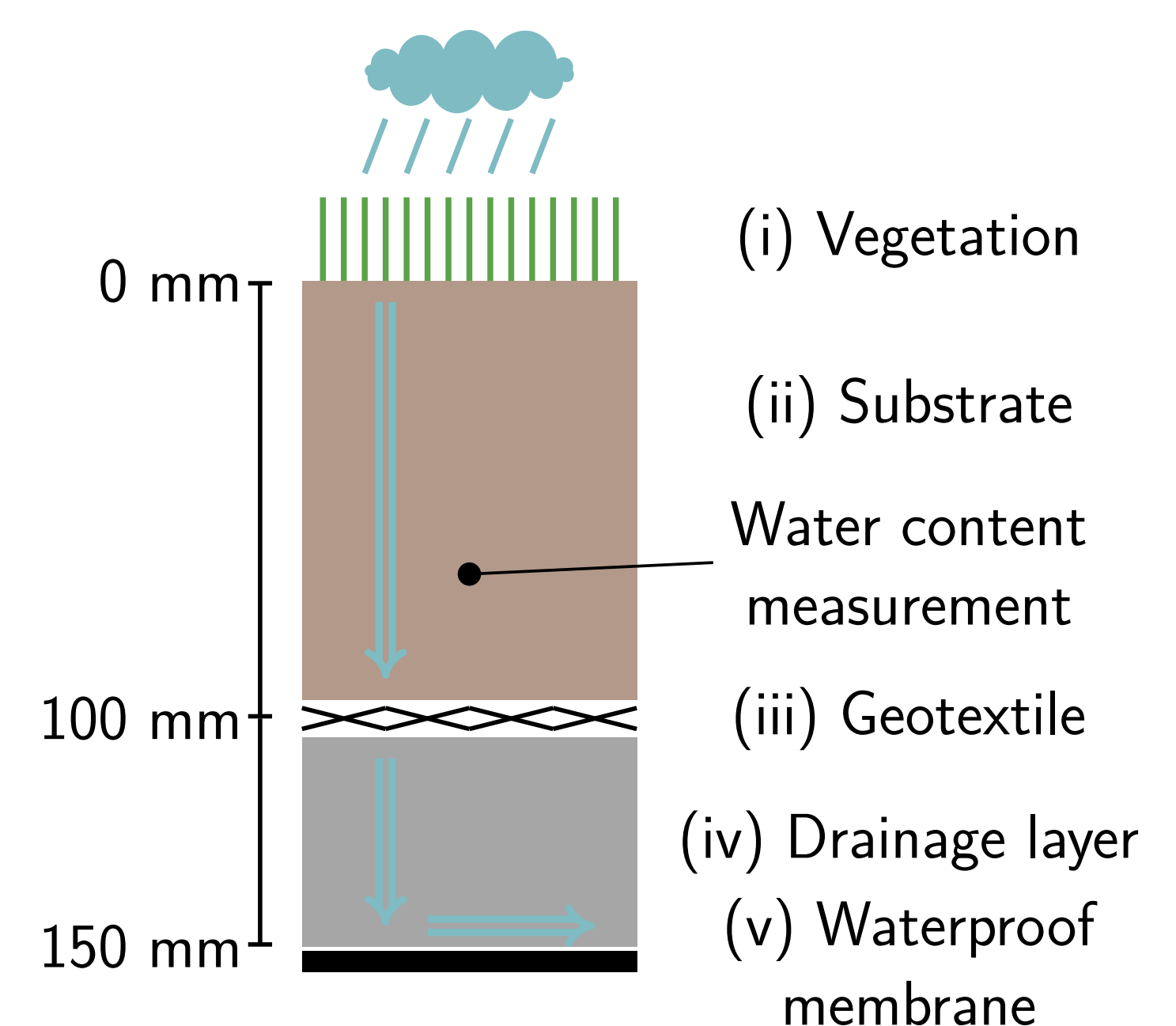


Figure 2 – Profile view of a green roof

Problem statement

- Input: Rainfall;
 - Output: Volumetric water content $\theta(t)$ in the substrate (ii) (Fig. 2);
 - 6 soil parameters: θ_s , θ_r , K_s , l , n and α ;
 - 5 meteorological variables;
 - 4 vegetation parameters: *CropHeight*, *LAI*, *Albedo* and *RootDepth*.
- 6 parameters are considered uncertain: θ_s , n , α , *CropHeight*, *LAI* and *RootDepth*

How to define these parameters to reproduce the real data ?
Which ones affect the water content (model output) ?

Sensitivity analysis

Sensitivity analysis allows to measure the effect of the parameters on model output.

- Objectives:
- Better understand the model behavior;
 - Prioritize the model parameters by identifying their influences on the output;
 - Focus on influential parameters and fix non-influential parameters.

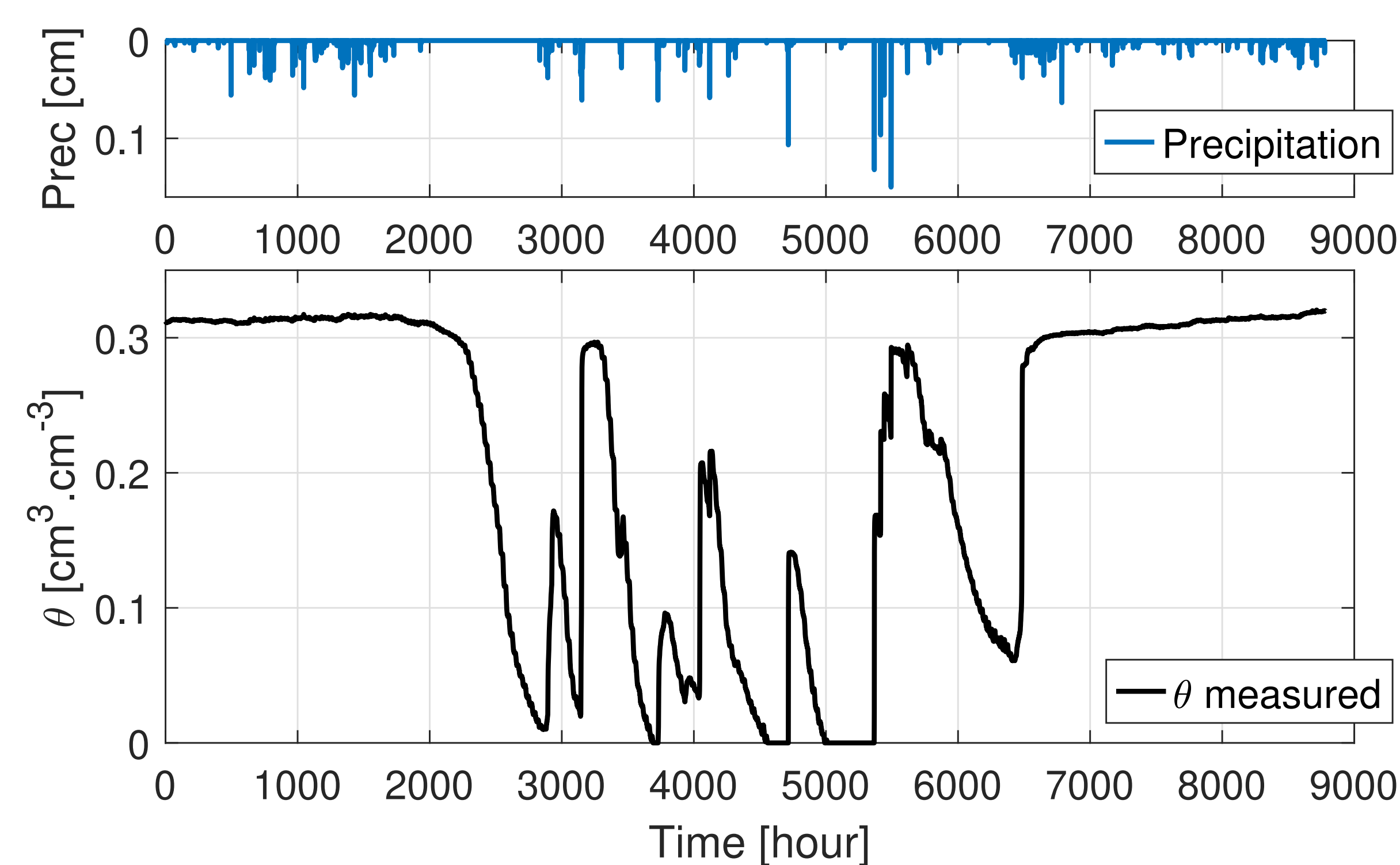


Figure 3 – Observed water content $\theta(t)$ and rainfall of 2020

How varies the water content $\theta(t)$ in the substrate when the uncertain parameters vary ?

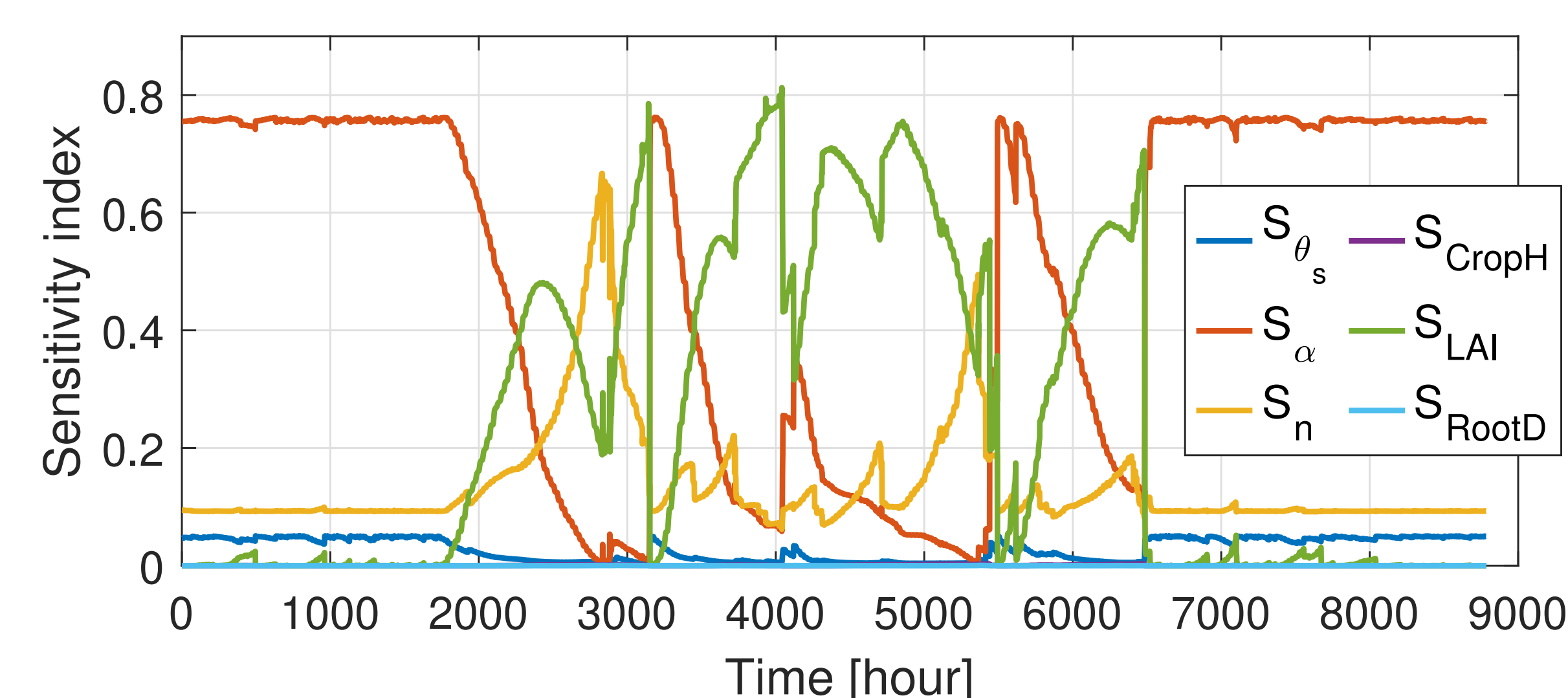


Figure 4 – Sensitivity indices $S_i(t)$ over time

- 3 parameters affect the water content θ : α (orange), n (yellow) and *LAI* (green)
- During humid period, α (orange) is the most influential
- During drying period, *LAI* (green) is the most influential

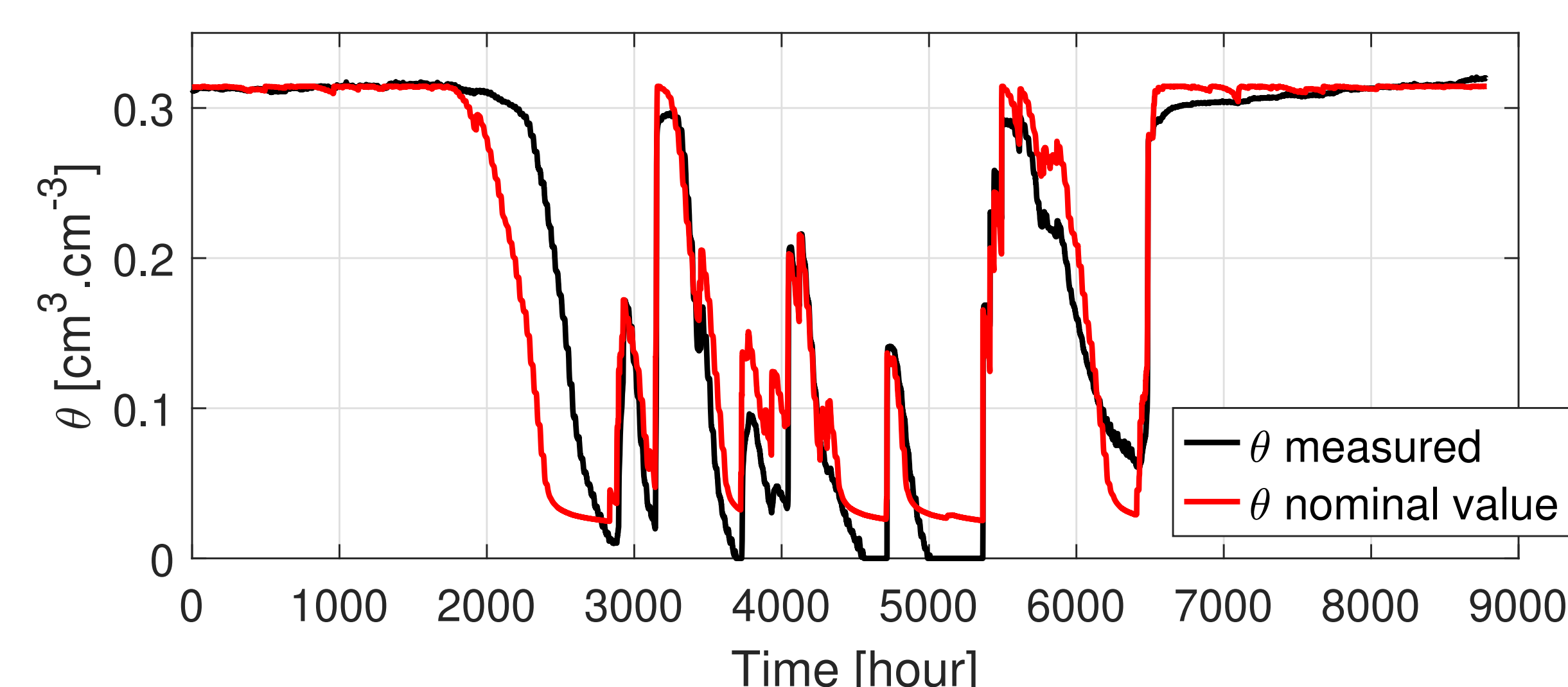


Figure 5 – Simulated water content $\theta(t)$ at nominal values

Calibration using sensitivity analysis results

- Which parameter values reduce error of simulation ...
- during humid period ? → set α
 - during drying period ? → set *LAI*
 - when it is influential ? → set n
- Non-influential parameters can be fixed to the mean value of the uncertainty interval (Fig. 5)

References

- Hégo A. et al. *Approaches for green roof dynamic model analysis using GSA*, IFAC-PapersOnLine, 54(7):613–618, 2021.
- Li Y. et al. *Green roof hydrologic performance and modeling: a review*, Water Science & Technology, 69(4):727–738, 2014.